
Space Weather Technical Forecast

Issued on Sunday, 31 December 2023 at 01:19 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales <https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales>

Space Weather Forecast Headline: Chance of M-flares. Slight chance G1-Minor storms from coronal hole fast wind onset day 2 (1st Jan).

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Low with occasional C-class flares, the largest a C6.1 at 30/2150 UTC from behind the west limb, from previous region AR3530. There are four sunspot regions on the disc, three of which are numbered. AR3534 in the southeast is the most significant, with small asymmetric penumbra on both leader and trailer spots, is classified as Dai/beta-gamma and was the source of some small C-class flaring. The remaining regions are magnetically simpler and either stable or weakly decaying.

There were several CME's observed through the period, with most being analysed as missing Earth. However, a small CME from a C-class flare from AR3534 may give Earth a weak glancing blow, but outside of the forecast period as the CME is so slow. There are notable filaments on the Earth-side of the Sun, including a large mobile filament in the northwest, however these are mainly rotating towards the western horizon with a lowering chance of any Earth-directed eruption.

Solar Wind / Geomagnetic Activity: Initial residual weak CME influences quickly faded. Background wind speeds were observed, initially between 350-400 km/s but ending the day around 335 km/s. Density started at average to above average levels, peaking at 21 ppcc at 30/0256 UTC, thereafter declining to end the day at below average levels. Interplanetary Magnetic Field (IMF), Bt, started at moderate levels of 10nT before easing to become weak. The north-south component, Bz, was mainly positive (northward) peaking +9nT, but with brief rotations to negative (southward) reaching a minimum of -5nT. Phi angle was mainly negative (towards the Sun), with brief period of positive (away from the Sun). Geomagnetic activity remained Quiet (Kp 0-2).

Energetic Particles / Solar Radiation: GOES16 high energy (greater than 10MeV) proton flux was at background. GOES16 high energy (greater than 2MeV) electron flux ranged diurnally between background and moderate levels. The 24-hour fluence was below Active throughout and has been slowly declining. The 31/0000 UTC observation was 5.34e6 integrated pfu.

Four-Day Space Weather Forecast Summary

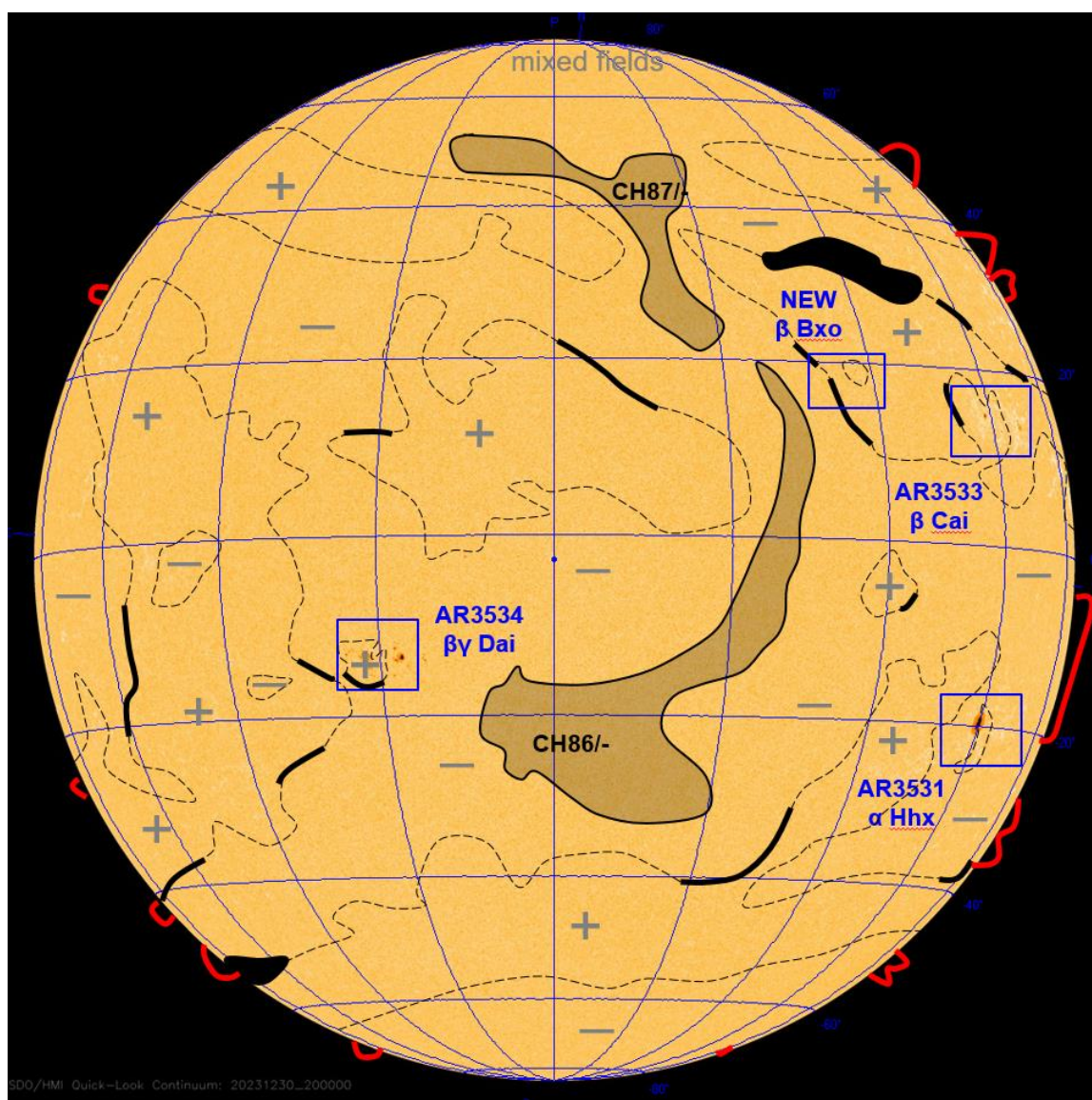
Solar Activity: Low activity is expected, but with a chance of rising to Moderate with isolated M-flares possible, these initially from AR3534 but then later in the period also from the expected return of ex-AR3514.

Solar Wind / Geomagnetic Activity: There are no Earth-directed CMEs within the forecast period. Slow wind conditions are expected until the arrival of the fast wind of CH86 tomorrow (1st Jan).

Elevated winds are forecast, around 500-550km/s, and likely persisting day 3 (2nd Jan). Quiet (Kp 0-2) geomagnetic activity at first, becoming Unsettled (Kp 3) tomorrow with a chance of Active (Kp 4) intervals and a slight chance of an isolated G1 Minor Storm (Kp 5) interval from the fast wind onset. Activity easing to Quiet with a chance of Unsettled intervals day 3 (3rd Jan) and then back to predominantly Quiet activity for day 4 (4th Jan).

Energetic Particles / Solar Radiation: GOES16 high energy proton flux is expected to remain at background levels. GOES16 high energy electron flux is likely to remain at background to moderate levels initially, before dropping out with any fast wind onset. The flux is then expected to reach Moderate levels, with a chance of reaching High at diurnal peaks, from day 3 (2nd Jan). The associated 24 hour fluence is expected to remain below Active through the period.

Figure 1. Solar Analysis Valid 30/2000 UTC.



Key: Filament —, Prominence —, Magnetic Field Line - - -, Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-γ-δ and Zurich-McIntosh Axx etc.

Geomagnetic Storms:

No Earth-directed CME's are expected within the forecast period.

Background wind conditions today are expected to become elevated tomorrow (1st Jan) due to the onset of fast winds from CH86/-. This is a recurrent feature, which produced Unsettled geomagnetic conditions with solar wind speeds 500-600km/s during the last rotation. This rotation the coronal hole is narrower, and so slightly slower wind speeds may occur, 500-550 km/s, similar to MOSWOC Enlil expectations.

Quiet (Kp 0-2) geomagnetic activity at first, becoming Unsettled (Kp 3) tomorrow with a chance of Active (Kp 4) intervals and a slight chance of an isolated G1 Minor Storm (Kp 5) interval from the fast wind onset. Activity easing to Quiet with a chance of Unsettled intervals day 3 (3rd Jan) and then back to predominantly Quiet activity for day 4 (4th Jan).

Geo-Magnetic Storm	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Minor or Moderate	G1 to G2	No	5	20	10	1
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Figure 2: SDO/AIA 211 images of CH86. Left – previous rotation. Right – current rotation.

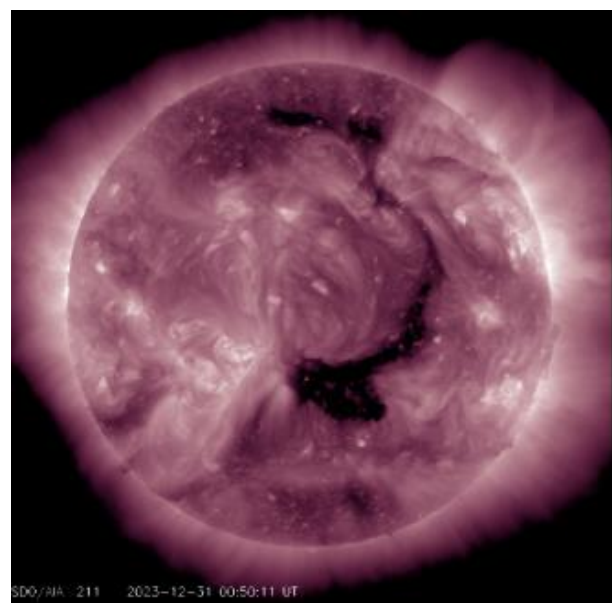
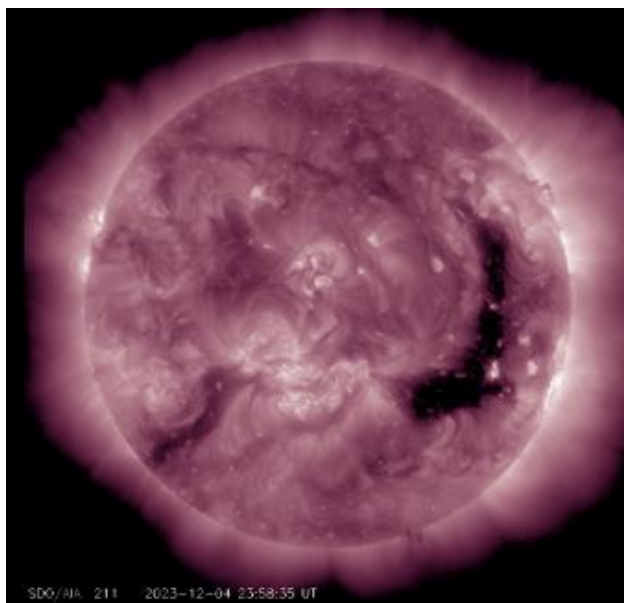
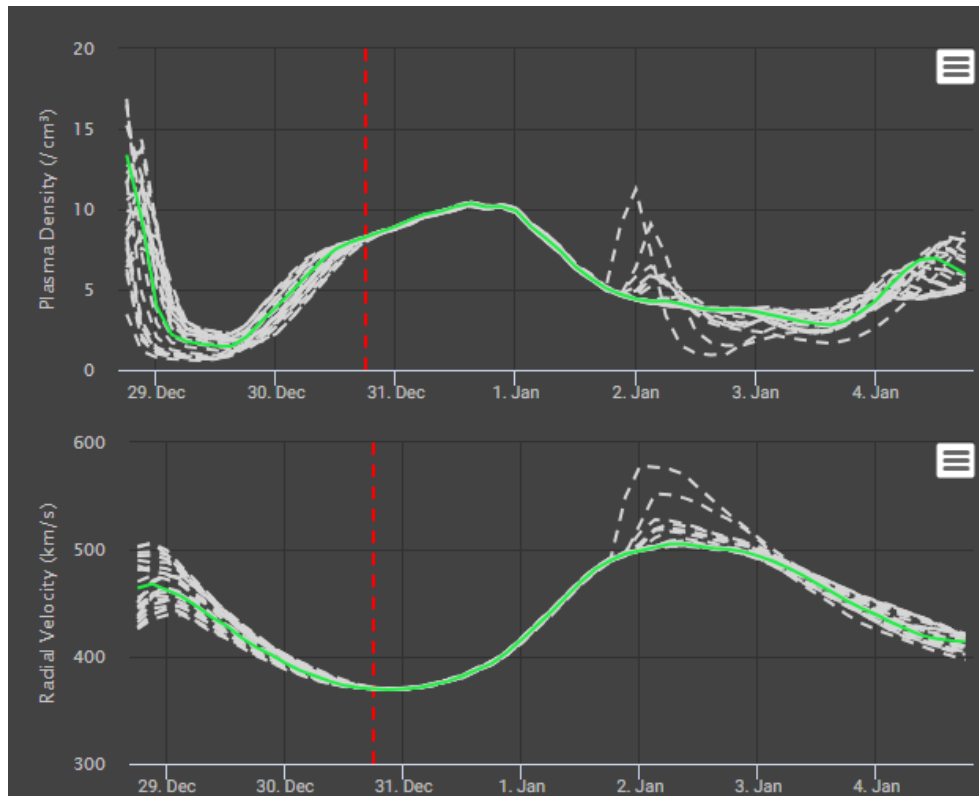


Figure 3: MOSWOC Enlil ensemble. Although no Earth-directed CME's are forecast a filament eruption CME from the southwest disc on 30th Dec has the potential to pass close to Earth on 2nd Jan, as indicated by a few ensemble members.



Radio Blackouts - X-Ray Flares:

Low activity is expected, but with a chance of rising to Moderate with isolated M-flares possible, these initially from AR3534 but then later in the period also from the expected return of ex-AR3514.

There are four sunspot regions on the visible disc, three of which are numbered, as AR3530 has now rotated off behind the west limb. The most notable region remains AR3534 which continues to show some very slow growth and is now classified as Dai/beta-gamma. Both AR3531 and AR3533 appear to show some signs of decay, although this could be due to the regions approaching the western limb and therefore becoming harder to analyse. Therefore the previous assessments are maintained. The remaining region is an unnumbered simple and small region in the northwest, which is also weakening and has almost faded from sight.

Far-sided products, including those from stanford.edu and from H-alpha imagery from NISP, both show the persistence of a strong feature that is expected to move onto the western limb tomorrow (1 Jan). This is likely associated with ex-A3514 which produced an X2.8 flare on 14 Dec, before moving onto the far-side. This region was visible to the Mars Perseverance rover on 22 Dec, but it remains uncertain how much of this region has persisted its transit across the disc, or how complex it remains. However, this does bring an increased likelihood of flare activity from tomorrow onwards.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	20	25	25	25
Very Active	R3 to R5 X Class	No	1	1	1	1

Solar Radiation Storms - (High Energy Protons):

GOES16 high energy (greater than 10MeV) proton flux is currently at background persist at this level. There remains a slight chance of minor increases, given any notable flares from the sunspots in the western hemisphere or just over the western limb, or from any notable filament eruptions.

Radiation Storms	Level (cm ⁻² sr ⁻¹ s ⁻¹)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ S1	No	5	5	5	5
Very Active	≥ S3 *	No	1	1	1	1

* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = cm⁻²sr⁻¹s⁻¹)

High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) has seen diurnal fluctuations between background and moderate. Flux is likely to drop out to mainly background with the onset of the fast wind of CH86, before increasing to Moderate from day 3 (2nd Jan) with a slight chance of peaking at High.

Electron fluence is expected to remain well below the Active (1e8 integrated pfu) threshold, but possibly with a gradually increasing trend from day 3 (2nd Jan) as a result of the fast wind onset. This is in line with REFM which is currently giving good guidance.

GEO Electron Environment	Level (cm ⁻² sr ⁻¹)	Past 24 Hours	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
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Probability (Exceedance)	day ⁻¹)	(Yes/No)	(%)	(%)	(%)	(%)
Active	$\geq 2 \text{ MeV}$ $\geq 1 \times 10^8$	No	1	1	1	1
Very Active	$\geq 2 \text{ MeV}$ $\geq 1 \times 10^9$	No	1	1	1	1

Figure 4: Met Office REFM model.

